COMPARISONS OF PRESCRIBED BURNING AND CUTTING OF UTAH MARSH PLANTS

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ABSTRACT.— The efficacy of cutting (haying) versus burning was compared for control of marsh vegetation in Utah. Cutting reduced production of hardstem bulrush (*Scirpus lacustris*), alkali bulrush (*S. maritimus*), and cattail (*Typha* spp.) compared to levels found on burned plots, but differences were significant ($P < 0.05$) only within the alkali bulrush vegetation type. Clipping saltgrass (*Distichlis spicata*) plots greatly reduced production upon reflooding, which produced results similar to prescribed burning and reflooding. Heat penetration into the sediments during the fire was not sufficient to cause substantial belowground mortality. Without belowground mortality, prescribed burning alone did not change aboveground production or species composition. Flooding after fire did eliminate saltgrass, but a single prescribed burning or cutting was not an effective management tool for reducing production of cattail, hardstem bulrush, and alkali bulrush.

Dense emergent marsh plants often restrict nesting and loafing by waterfowl. Wetland managers attempt to reduce the density of emergent marsh plants with prescribed burning or cutting (haying) (Nelson and Dietz 1966, Linde 1969). Smith and Kadlec (1985a) detailed the effects of fire on cattail (*Typha* spp.), saltgrass (*Distichlis spicata*), hardstem bulrush (*Scirpus lacustris*), and alkali bulrush (*S. maritimus*). In this study the objective was to compare the effects of cutting relative to fire on primary production of these four vegetation types and to assess the impact of heat penetration into the soil on aboveground plant response. Although some data exist for cattail (Nelson and Dietz 1966), little has been published regarding heat penetration and the cutting of the other vegetation types.

Study Area

The study was conducted at Ogden Bay Waterfowl Management Area, Weber County, Utah. The area was established in the 1930s and 1940s when dikes were constructed along the shore of the Great Salt Lake that entrapped freshwater from the Weber River (Nelson 1954). Four species dominated the emergent vegetation: saltgrass, alkali bulrush, hardstem bulrush, and cattail (Smith and Kadlec 1983). Botanical nomenclature follows Cronquist et al. (1977) and Scoggan (1978).

Unit 1 of Ogden Bay (see Nelson 1954 for detailed description) was drained in April 1981. Portions of the area were burned 2 September 1981. The fire removed all aboveground plant material. There was a wind speed of 16.6 km with a mean dew point of 5 C and a maximum temperature of 28.5 C on the day of the fire (Smith et al. 1984).

Methods

Annual production was determined in burned and unburned sites for cattail, alkali bulrush, hardstem bulrush, and saltgrass communities. Five quadrats in each vegetation type within the unburned area were clipped at the substrate level and raked when the other plots were burned. Quadrat size was 1.0×0.5 m in cattail, alkali bulrush, and hardstem bulrush sites and only 0.25×0.25 m within saltgrass sites due to its smaller size and high shoot density (see below). Five quadrats in each vegetation type were also established within the burned area.

Standing crops were estimated six times (May–August) during 1982 using length-mass regressions on tagged shoots (Smith and Kadlec 1985b) of alkali bulrush, hardstem bulrush, and cattail. Because water depths influence plant recovery, depths were also recorded throughout the season in burned and mowed plots. Total annual production

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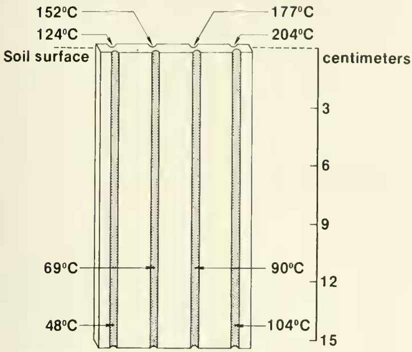

Fig. 1. Schematic of asbestos board illustrating spacing of depressions that contained waxes with a specific melting point. Boards were used to indicate temperature gradient within the soil during prescribed burning at Ogden Bay Waterfowl Management Area, Utah, 1981.

and mowed plots. Total annual production was calculated by incorporating mortality of tagged shoots. Because of the dense nature of saltgrass (2000 shoots/m^2), seasonal estimates of biomass were not made and total production was estimated using clipped plots at peak standing biomass. Biomass was also estimated for the proposed burned and unburned areas for all species prior to treatment. If pretreatment estimates of biomass were different among proposed treatment sites, pretreatment biomass was used as a covariate in subsequent analyses of variance (Steel and Torrie 1980). Data were square root transformed according to Zar (1974) to conform with normal variate assumptions.

Heat penetration into the soil during the prescribed burn was estimated by using 7 asbestos strips (Fig. 1) within each vegetation type. Each strip had waxes with 8 different melting points. Tops of the strips were placed flush with the soil surface prior to the fire (Shearer 1975). Temperature profile in the soil during the fire was reconstructed by linearly measuring the depth to which the various waxes had melted. Mortality of roots and rhizomes was estimated by taking 20 randomly located soil cores (5.0 × 15.2 cm) within each vegetation type immediately prior to and after the prescribed burn. The number of living roots and rhizomes was counted at 4 depths: 0–3.8, 3.8–7.6, 7.6–11.4, and 11.4–15.2 cm. A solution of orthotolidine $(C_6H_3\text{-}4NH_2\text{-}3\text{-}CH_3)_2$ in 95% methanol and a 3% hydrogen peroxide (H_2O_2) solution (Hare 1965, Shearer 1975) were sprayed on the surface of the flattened core. Living material reacted by producing a blue color, but dead material did not change in color.

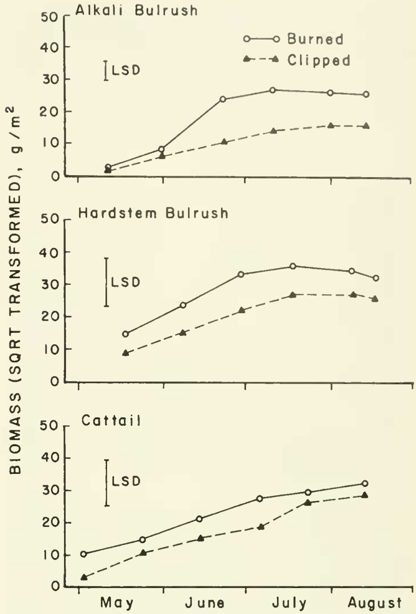

Fig. 2. Comparisons of standing crops among burning and clipping treatments within cattail, hardstem bulrush, and alkali bulrush vegetation types ($P = 0.05$; LSD = 14.2, 15.1, 6.0, respectively) at Ogden Bay Waterfowl Management Area, Utah.

RESULTS

Smith and Kadlec (1985a) demonstrated that burning did not affect the subsequent annual production of hardstem bulrush, alkali bulrush, or cattail, but saltgrass was virtually eliminated as a result of flooding following fire. In this study, standing crop biomass on clipped plots was consistently less than on burned plots (Fig. 2), but the difference was significant ($P < 0.05$) only within the alkali bulrush vegetation type. Total annual production results also indicated a significant ($P < 0.05$) reduction in clipped versus burned plots (Table 1) only within the alkali bulrush sites. Within saltgrass sites cutting was similar ($P > 0.05$) to prescribed burning in that little vegetative biomass was produced following clipping and reflooding. Water depths following the prescribed burn were not different ($P > 0.15$) among burned and clipped plots, respectively, for saltgrass (8.0, 10.2 cm), cattail (22.2, 16.8 cm), hardstem bulrush (14.2, 15.0 cm), and alkali bulrush (16.8, 16.4 cm). Therefore, water levels in the two areas were not a factor in production differences.

Heat penetration into the soil (Table 2) sufficient to kill (Shearer 1975) plant tissue (60 C) was minimal but greatest within saltgrass and alkali bulrush vegetation types. Temperatures within the 48–69 C range were never deeper than 3.8 cm.

In cattail, the number of living roots and rhizomes decreased after the prescribed burn at all 4 depths (Table 3; $P < 0.05$). There was no decrease ($P > 0.20$) in the upper 3.8 cm of sediment in hardstem bulrush sites; however, differences were evident ($P < 0.05$) in the three deepest zones. Within alkali bulrush sites differences existed ($P < 0.05$) in the number of living roots and rhizomes for the three most shallow categories but not ($P > 0.10$) in the 11.4–15.2 cm range. Saltgrass sites also did not show a difference ($P > 0.20$) in the number of roots and rhizomes in the upper 3.8 cm, but differences were evident ($P < 0.05$) in the three deepest categories.

TABLE 1. Mean annual production ($g \cdot m^{-2} \cdot yr^{-1}$) of 4 vegetation types under clipping and burning treatments at Ogden Bay Waterfowl Management Area, Utah.

Vegetation type	Burned	Clipped
Distichlis spicata[a,b]	89(122)[c]	268(179)
Scirpus lacustris	1559(811)	920(612)
Scirpus maritimus	849(229)	319(129)
Typha spp.[b]	1173(1161)	979(616)

[a]Peak standing biomass
[b]Not adjusted for covariate
[c]Standard deviation in parentheses

DISCUSSION

Data on rhizome mortality and heat penetration provided insight into the effects of prescribed burning on aboveground vegetative-reproduction. Cattail and alkali bulrush sites were the only vegetation types where differences in the number of living roots and rhizomes occurred in the upper 3.8 cm of soil (Table 3). This zone is where temperature during the fire was greatest (Table 2) and suggests that the prescribed burn may have caused belowground plant mortality in these two cases. However, most vegetation types

TABLE 2. Mean heat penetration (cm) into the soil, within 4 vegetation types, during a prescribed burn at Ogden Bay Waterfowl Management Area, Utah, 1981.

	Temperature (C)							
Vegetation type	48	69	90	104	124	154	177	204
Distichlis spicata	2.21 (0.63)[a]	1.56 (0.51)	1.01 (0.24)	0.77 (0.37)	0.60 (0.45)	0.29 (0.23)	0.13 (0.11)	0.07 (0.10)
Scirpus lacustris	1.91 (0.83)	1.33 (0.72)	0.89 (0.66)	0.63 (0.57)	0.49 (0.55)	0.29 (0.36)	0.13 (0.19)	0.03 (0.08)
Scirpus maritimus	2.34 (0.70)	1.84 (0.61)	0.93 (0.30)	0.69 (0.29)	0.37 (0.21)	0.13 (0.11)	0.06 (0.05)	0.03 (0.05)
Typha spp.	1.50 (0.85)	1.01 (0.65)	0.64 (0.52)	0.43 (0.46)	0.28 (0.29)	0.13 (0.18)	0.08 (0.12)	0.04 (0.07)

[a]Standard deviation in parentheses

TABLE 3. Mean number of living roots and rhizomes at four depths in four vegetation types prior to and after a prescribed burn at Ogden Bay Waterfowl Management Area, Utah, 1981.

	Depth range (cm)							
	Prefire				Postfire			
Vegetation type	0.0–3.8	3.8–7.6	7.6–11.4	11.4–15.2	0.0–3.8	3.8–7.6	7.6–11.4	11.4–15.2
Distichlis spicata	2.8 (1.4)[a]	2.9 (1.4)	3.0 (1.6)	2.2 (1.6)	2.3 (1.3)	2.0 (1.1)	1.7 (1.1)	1.1 (1.0)
Scirpus lacustris	0.8 (0.6)	1.3 (0.9)	1.7 (0.9)	1.4 (0.7)	0.6 (0.9)	0.7 (0.7)	0.7 (0.7)	0.5 (0.8)
Scirpus maritimus	2.4 (1.1)	2.0 (0.7)	1.3 (0.8)	0.6 (0.8)	1.0 (0.9)	1.4 (1.0)	0.8 (0.8)	0.2 (0.5)
Typha spp.	1.5 (1.0)	1.6 (0.7)	1.3 (0.9)	1.1 (0.8)	0.8 (0.7)	0.8 (0.6)	0.9 (0.5)	0.4 (0.5)

[a]Standard deviation in parentheses

had decreases in the number of living roots and rhizomes in the three deepest sediment categories, where lethal heat penetration into the soil was not common. Mortality that occurred at these depths therefore should be regarded as non-fire-induced, and perhaps that was also true in more shallow layers.

Therefore, decreases in the number of roots and rhizomes in the three deepest categories (3.8–15.2 cm) were natural or resulted from the drawdown preceding the fire, which caused decreased soil moistures and increased salinities. (Smith and Kadlec 1983). Valiela et al. (1976) noted that biomass of cordgrass (*Spartina* spp.) roots peaked in midsummer and declined through autumn. At Farmington Bay Waterfowl Management Area, Utah, Anderson (1977) found that, under the stress of increased salinity, the growth of a fungus (*Chaetophoma confluens*) was encouraged on the surface of cattail rhizomes. Anderson noted the fungus was consistently associated with rhizomes of declining plants. Because the aboveground production of cattail and alkali bulrush was not reduced following fire (Smith and Kadlec 1985a), belowground decreases were apparently unimportant in terms of potential control of these vegetation types. In contrast, the decrease of saltgrass biomass was not due to fire per se because there was no decrease in living roots and rhizomes. Saltgrass decreases therefore were likely due to fire and reflooding acting together.

Faulkner and de la Cruz (1982) found that both increased soil temperature and slight increases in sediment nutrients (from fire residue) may have aided vegetation recovery and resulted in increased nutrient levels found in plant tissues after fire. At Ogden Bay, biomass of clipped plots were consistently lower than burned plots (Fig.2), suggesting that nutrients released by the fire may have speeded vegetation recovery. De la Cruz and Hackney (1980) compared clipped and burned plots within a cordgrass marsh and stated, "Presumably, nutrients left by the ash enhanced the growth of plants in the burned area." Nitrogen levels of the postburn vegetation increased in some species at Ogden Bay (Smith et al. 1984), which suggests a possible nutrient effect. An alternative hypothesis is that fire caused enough rhizome mortality to reduce intraspecific competition and allow increased vigor in individual shoots, such as cattail at Ogden Bay (Smith and Kadlec 1985a), which resulted in vegetative recovery.

CONCLUSIONS

Controlled burning has been used with limited success to control dense and undesirable plants such as cattail, *Phragmites*, and cordgrass (Lay 1945, Nelson and Dietz 1966, Ward 1968). Reasons cited for poor control include lack of proper water levels and little belowground mortality. Nelson and Dietz (1966) reported that cattail could be controlled if the area was flooded to greater than 45 cm immediately after fire. Water levels of that depth are often difficult to attain. In this study sediments were dry (Smith and Kadlec 1983) and heat penetration into the sediments was slight, resulting in little belowground plant mortality. Sediments of higher organic content might allow greater belowground mortality and better overall control. Control of saltgrass through burning or cutting and subsequent reflooding was effective. However, saltgrass is usually considered as good nesting cover for waterfowl and seldom is control warranted.

Mowing (haying) may be more effective, albeit probably temporary, than a single fire for control of emergent macrophytes, which may be due to the availability of ash (nutrients) on burn plots. Clipped plots did not receive this pulse of nutrients.

Also, rather than using vegetative removal methods to reduce cattail, salinity manipulations may promote more desirable species. Dropping water levels may lead to increased salinity (Smith and Kadlec 1983) favoring alkali bulrush. Nelson and Dietz (1966) found that cattail plots dried for two years (thereby increasing salinity) and mowed often showed increases in alkali bulrush.

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